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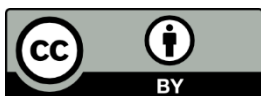
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Explaining the Media's Framing of Renewable Energies: An International Comparison

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The use of renewable energies has been rapidly expanding worldwide; however, in numerous countries this has resulted in public controversy. Building upon Entman's framing concept, a quantitative content analysis was conducted to examine the media's framing of renewable energies in 11 countries between 2010 and 2012. To explain the observed differences in media coverage, we considered national structural conditions. Furthermore, we investigated whether media framing changed after an external shock, the Fukushima accident. The findings show that renewable energies were covered through three different frames, (1) the first highlighting economic and technological problems, (2) the second focusing on environmental and social problems and (3) the third considering positive aspects of the technologies. To some extent, the occurrence of these frames is influenced by the national structural conditions. The study revealed that the Fukushima accident did not cause the expected changes in framing.

Keywords: renewable energy, content analysis, framing, institutional theory, focusing events, Fukushima accident, comparative research

INTRODUCTION

In response to climate change, many countries have recently intensified their energy policy activities to increase the proportion of renewable energy in their supply systems (REN21, 2011). Because climate change is a global issue, the implementation of renewable energy as a mitigation strategy should be an important topic in countries around the world. Despite this global relevance, the political decisions to deploy these technologies are only considered on national or regional scales. Previous media content research on renewable energy has shown that in many countries, the general provision of energy supply and the development of renewable energy sources in particular are politically controversial with regard to infrastructural, economic, societal and ecological aspects (Haigh, 2010; Devine-Wright, 2011; Hindmarsh, 2014; Kim et al., 2014). These controversies have led to country-specific public debates on energy policy. Because mass media are the most important platforms for providing information, arguments and forums for discussions about relevant topics, we assume that the national debates on renewable energies can be reconstructed by analyzing the content of national and regional media in a country.

In democratic societies, the production of media content is the result of a complex process involving many actors and influencing factors. The seminal hierarchical influences model by Shoemaker and Reese (1991, 2014) systemises the factors influencing journalists' work and media coverage from the micro to the macro level. The model considers individual and routine practices of journalists and acknowledges the impact of media organizations and professional contexts. Furthermore, it recognizes the influence of social institutions and the role of the social system, including public opinion. Thus, the media become the place where external

sources, such as governmental officials, politicians, activists and scientists, express and contest frames on an issue. In addition to articulating public opinion, journalists and media contribute to the emerging picture of an issue. Consequently, the discourse between external sources, media organizations, journalists and the public is developing and “operating in the universe of shared culture and on the basis of socially defined roles” (Pan and Kosicki, 1993, p. 55). Because this process occurs continuously in the form of looping circles and is changing over time, it can be described as “cultural circuits” (Carvalho and Burgess, 2005, p. 1459).

While the original hierarchical influences model proposed by Shoemaker and Reese (1991) focused exclusively on sociological factors, a more recent update of the work (Shoemaker and Reese, 2014) also considers influencing factors. As a first factor we refer to *natural structural conditions*. In the context of the current study, these natural structural conditions are defined as any relevant factor interrelated with the deployment of renewable energies within a certain territory (local, regional or national). This includes the potential, demand, supply and usage of energy resources. Previous research has shown that such factors might play a role in how renewable energy is covered in the media (Skjølsvold, 2012; Deignan and Hoffman-Goetz, 2015; Djerf-Pierre et al., 2015). The second factor is a *focusing event*, in this case the Fukushima nuclear catastrophe. As previous research has shown that the Fukushima accident affected the public perception of renewable energies in some countries (Biddinika et al., 2014; Park et al., 2016), it is assumed that the portrayal of renewable energies in the media might have benefitted from this focusing event as well, since they may appear to be less dangerous than nuclear energy.

Thus, this study has two aims. The first aim is to examine how the media coverage on renewable energy in countries with different energy supply systems. The second aim is to explain differences in the respective national media coverage based on two different types of influencing factors: (1) *natural structural conditions* and (2) a *focusing event*.

In the following section, the existing literature on the media coverage of renewable energy as well as the influence of national structural conditions and focusing events on this coverage are reviewed. Furthermore, several theoretical frameworks that systemise these factors are discussed. Based on these frameworks, a research model is introduced, research questions are specified and the methodology applied to address them is described. Finally, the results are presented and discussed along with implications and limitations.

FRAMING RENEWABLE ENERGY IN THE MEDIA

Almost all existing research on the media coverage of renewable energy relies on the concept of framing (Qu et al., 2009; Stephens et al., 2009; Haigh, 2010; Sengers et al., 2010; Heras-Saizarbitoria et al., 2011; Wright and Reid, 2011; Kim et al., 2014; Djerf-Pierre et al., 2015; Zukas, 2015; Ehlers and Sutherland, 2016; Smith et al., 2016). Entman (1993, p. 52) defined the concept of framing as “to

select some aspects of a perceived reality and make them more salient in a communicating text, in such a way as to promote a particular problem definition, causal interpretation, moral evaluation and/or treatment recommendation.” As renewable energy is a contested political issue, framing is a useful concept to examine media coverage on the topic.

Existing media research has revealed that the media coverage on renewable energies is dominated by *economic and technological aspects* (Haigh, 2010; Sengers et al., 2010; Heras-Saizarbitoria et al., 2011; Wright and Reid, 2011; Skjølsvold, 2012; e.g., Eklöf and Mager, 2013; Hindmarsh, 2014; Romanach et al., 2015; Stauffacher et al., 2015). However, *environmental aspects* of renewable energies, including problems and benefits, also play a major role in media coverage (Thompson, 2005; Hindmarsh, 2014; Kim et al., 2014; Djerf-Pierre et al., 2015). Scholars have also observed that *social aspects*, such as highlighting social conflicts in the context of the implementation of energy infrastructure projects, have recently gained more attention in the news (Devine-Wright, 2011; Einsiedel et al., 2015). Taken together, *economy, technology, environment and society* have been identified as relevant dimensions in framing renewable energies; therefore, these four dimensions were also considered in the current analysis.

The review of existing investigations has also shown that the body of research is still limited and that most studies focus on media coverage in developed Western nations.¹ However, despite the limited number of existing studies, many have followed a comparative approach. Some have compared how renewable energies were framed in multiple regions within one country (Stephens et al., 2009; Haigh, 2010; Hindmarsh, 2014; Kim et al., 2014), while others have compared the coverage in two countries (Skjølsvold, 2012; Djerf-Pierre et al., 2015). In climate change research, several studies have demonstrated the explanatory power of a broader cross-national approach including more countries (Barkemeyer et al., 2013, 2017; Schmidt et al., 2013). However, to date no such study exists concerning the discourse on renewable energies. Therefore, it is important to broaden the scope and include developed and emerging countries from different parts of the world to identify relevant factors influencing media coverage (Livingstone, 2003).

NATIONAL STRUCTURAL CONDITIONS AS INFLUENCING FACTORS ON THE FRAMING OF RENEWABLE ENERGIES

The existing research indicates that the way the media cover renewable energies differs between countries (Skjølsvold, 2012;

¹Use of the term media studies here refers to studies that include data about mass media coverage in the analysis. Studies from the US include Delshad and Raymond (2013), Haigh (2010), Kim et al. (2014), Smith et al. (2016), Stephens et al. (2009), Thompson (2005), Wright and Reid (2011), and Zukas (2015). Studies from Europe include Devine-Wright (2011), Djerf-Pierre et al. (2015), Ehlers and Sutherland (2016), Eklöf and Mager (2013), Heras-Saizarbitoria et al. (2011), Sengers et al. (2010), Skjølsvold (2012) and Stauffacher et al. (2015). Studies from Asia include Biddinika et al. (2014) and Qu et al. (2009). Studies from Australia include Djerf-Pierre et al. (2015), Hindmarsh (2014) and Romanach et al. (2015). One study examines Canada (Deignan and Hoffman-Goetz, 2015).

Djerf-Pierre et al., 2015). Based on this observation, a question arises regarding how these differences can be explained. Based on the logic of institutional theory (Jepperson, 2008; Napoli, 2014), it is assumed that differences in the framing of renewable energy can be explained by specific structural conditions in each country. Institutional theory states that institutions are embedded in cultural norms, ideologies, routines and beliefs. From this perspective, national media organizations follow national priorities and interests, which in turn are influenced by the basic conditions of each country. Moreover, Barkemeyer et al. (2013) argued that national-level institutions have the ability to shape individual-level decision-making. Following this line of argumentation, journalists' decision-making may be influenced by their respective national media system and the structural conditions of their country. This assumption is also in line with the widely recognized hierarchy of influences model (Shoemaker and Reese, 1991, 2014).

Various studies have supported the notion that structural conditions affect media coverage on renewable energy, either on a regional (Stephens et al., 2009; Haigh, 2010; Hindmarsh, 2014; Kim et al., 2014) or a national level (Skjølsvold, 2012; Djerf-Pierre et al., 2015). For example, in the US, regional media in oil extracting states contained more opposition to biofuels than media in states that produce ethanol (Kim et al., 2014). Additionally, Australian newspapers have paid considerable attention to solar and wind energy, apparently because of the abundant potential in the country, whereas Swedish media have focused more on opportunities related to bioenergy, mainly because Sweden has plentiful natural resources to produce biofuels (Djerf-Pierre et al., 2015). Therefore, previous findings support the idea that national structural conditions may influence media coverage on renewable energies; nevertheless, as all comparative research was limited to a few countries, the current state of research is still inconclusive. Consequently, the conclusions of this research were predominantly based on plausibility rather than statistical validation.

Based on our theoretical considerations and the aforementioned findings, we propose the following hypotheses:

H1: In countries with many conventional energy resources (fossil fuels/nuclear energy), the media frame renewable energies more negatively than in countries with fewer conventional energy resources.

H2: In countries that use nuclear energy, the media frame renewable energies more negatively than in countries that do not use nuclear energy.

The dimension of conventional energy resources is referred to as energy production derived from gas, oil, coal (both anthracite and lignite) and uranium (nuclear).²

Existing research from several countries shows that people's acceptance of renewable energy depends on factors such as assumed economic consequences and perceived landscape

impacts (Olson-Hazboun et al., 2016), place attachment and "not in my backyard" attitudes (Liebe and Dobers, 2019), trust in responsible agents and the perception of having influence over major decisions regarding renewable energy projects (Liu et al., 2019). However, conflict between supporters and opponents of renewable energy is often unavoidable (Devine-Wright, 2011; Haggett, 2011). The probability that such conflicts arise is higher in densely populated countries with already intense usage of renewable energies because there is a higher chance that people are directly faced with such facilities. Because journalists have to consider the perspective of their audience in the continuous process of news production (Pan and Kosicki, 1993; Carvalho and Burgess, 2005), media coverage on renewable energy will most likely articulate the perspective of the audience's acceptance of or opposition to renewable energy. Therefore, the following hypothesis is proposed:

H3: In countries that have a high density of installed renewable energy facilities, the media frame renewable energy more negatively than in countries with a lower density of renewable energy installations.

FOCUSING EVENTS AS INFLUENCING FACTORS IN THE FRAMING OF RENEWABLE ENERGIES

Apart from national structural conditions, which are mostly stable and change only slightly over time, we assume that focusing events could also influence the framing of renewable energy. A focusing event is "sudden, relatively rare, can be reasonably defined as harmful or revealing the possibility of potentially greater future harms, inflict harms or suggest potential harms that are or could be concentrated on a definable geographical area or community of interest, and that is known to policy makers and the public virtually simultaneously" (Birkland, 2010, p. 22). Hence, the theory of focusing events, which is rooted in the theory of agenda setting, explains policy changes after certain unexpected events by the interests of political actors using these events to mobilize support for change (Birkland, 2010). In the current study, we argue that the nuclear catastrophe of Fukushima Dai-Ichi in March 2011 can be considered a focusing event that may have the potential to change the framing of renewable energies and promote political change.

We suspect this because the framing of nuclear power has already changed several times due to external events. Initially, when energy production using nuclear power was introduced, it was predominantly framed as technological progress and a cheap and reliable way to overcome fossil fuel dependency. However, in light of the incidents at Three Mile Island and Chernobyl, it was frequently reframed as dangerous, and renewable energies were discussed as environmentally friendly alternatives (Gamson and Modigliani, 1989). However, the framing of nuclear power changed once again in view of the growing perceived threat of climate change. In this context, it was politically reframed as a technological solution for reducing global warming (Carvalho, 2005; Doyle, 2011) and as an appropriate technology for bridging the time between the fossil age and the renewable age (Arlt,

²Data for these dimensions were retrieved from Weltalmanach.de. For the dimension of renewable energy production in each country, data on renewable energy production from the International Energy Agency were used. Detailed information on the amount of energy production for each dimension is available in **Supplementary Table 1**.

2013). Therefore, it seems reasonable to expect that the framing has changed again after the Fukushima incident, endowing renewable energies with more support. The Fukushima event is extremely suitable for international comparison because it evoked public attention all over the world, creating an almost quasi-experimental situation for research.³

Findings from Germany and Sweden have confirmed that the Fukushima catastrophe had the potential to change the media's framing of renewable energy sources (Zeh and Odén, 2014). After the Fukushima accident, the German media emphasized technical, security and environmental aspects, while the Swedish media focused more on technical aspects but less on security and environmental aspects. The German media also emphasized the need for changes in energy consumption and production (using alternative energy sources) more frequently than the US media did (Park et al., 2016). Thus, it is plausible to expect that the Fukushima accident affected the framing of renewable energies. Therefore, the following is hypothesized:

H4: After the Fukushima nuclear accident, the media frame renewable energies more positively than before the accident.

While hypothesis H4 suggests an overall positive effect of the Fukushima incident on the media's framing of renewable energies, it also seems plausible that this effect is particularly applicable to countries that use nuclear energy, as the public's pressure on politicians to search for alternative energy sources might be stronger in these countries. However, in countries that do not use nuclear energy, the need to rethink the structure of the national energy supply might be perceived as less pressing. This assumption is supported by a content analysis of the regional media coverage in Indonesia, which does not depend on nuclear power plants; therefore, the government showed little intention to foster the development of renewable energy, even after the Fukushima catastrophe (Biddinika et al., 2014). The following hypothesis is thus proposed:

H5: In countries that use nuclear energy, the media have framed renewable energies significantly more positively since the Fukushima nuclear accident, while in countries that do not use nuclear energy, the media frame renewable energy only slightly more positively.

METHODS AND DATA

Country Selection

To answer these research questions, a quantitative content analysis on the media's framing of renewable energy in 11 democratic countries was conducted. We selected democratic countries because in countries with other political systems, the process of news production and public debate differs considerably. To demonstrate the influence of dissimilar national structural conditions, countries that differ in terms of their geographical and economic conditions were selected according to the logic of comparative studies. Additionally, the availability

of study material and the language skills of the researchers and coders (English, German, and Indonesian) had to be considered. The differences in the national structural conditions relating to the production of fossil fuels, nuclear power and renewable energy (see **Supplementary Table 1**) were examined. This resulted in the following countries: Australia and New Zealand (industrialized countries in Australia and Oceania); the US and Canada (industrialized countries in North America); Ireland, Great Britain, Austria and Germany (industrialized countries in Europe); and South Africa, Indonesia and India (newly industrialized countries in Africa and Asia). To examine the potential changes in media coverage before and after the Fukushima accident, two time periods were studied: January 1, 2010 to March 10, 2011 (before the Fukushima accident) and March 12, 2011 to June 30, 2012 (after the Fukushima accident).

Sample

For each country, the media sample was comprised of two national daily newspapers⁴ with high circulation archived in the LexisNexis database. In the case of Indonesia, newspaper articles were obtained from Databott, a company offering a comparable service to LexisNexis. We decided to analyse print media mainly because of practical considerations, acknowledging that the framing might have been different, e.g., in broadcast media. Nevertheless, we believe that print media are still an important source of information, especially for decision makers. Therefore, the discourse in the print media can be regarded as a proxy for public debate and hence an appropriate object for our analysis.

The selection of newspapers should cover a broad range of positions on renewable energies within the countries. Therefore, newspapers with different political leanings were selected. However, as an ideological assignment was not possible in some countries, newspapers from different media companies were chosen.⁵ Although political leanings may influence how journalists frame renewable energies, this aspect was not in the scope of this paper for two reasons. First, the primary interest was on the influence of structural conditions, which belong to a different level according to the hierarchy of influences model (Shoemaker and Reese, 1991, 2014). Second, the media systems of the countries under investigation were not homogeneous; thus, it was not possible to label the newspapers in all countries with the same political classifications.

To select the articles, a database search was conducted within each newspaper using a comparable search string. As the usage of renewable energies depends on specific climatic and physical conditions, we selected four types of renewable energies differing

⁴New Zealand was an exception; in this country, we analyzed three newspapers because of the limited coverage on the topic in the first two.

⁵The newspapers in the sample are Australia: *The Australian* and *The Age* (Melbourne); New Zealand: *The Dominion Post*, *New Zealand Herald* and *The Press*; US: *The Washington Post* and *The New York Times*; Canada: *The Globe and Mail* and *Toronto Star*; Ireland: *Irish Independent* and *The Irish Times*; Great Britain: *Daily Mail* and *The Guardian*; Austria: *Der Standard* and *Die Presse*; Germany: *Die Welt* and *die Tageszeitung*; South Africa: *Sowetan* and *The Star*; Indonesia: *Kompas* and *Koran Tempo*; and India: *Times of India* and *Hindustan Times*.

³The event was extensively covered in the media of the countries we analyzed (see next chapter). In the two newspapers we analyzed in each country, we identified between 35 (New Zealand) and 416 (Germany) articles on the Fukushima disaster in the first three weeks after the incident.

TABLE 1 | Percentage of sampled articles on renewable energy technologies.

Country		Number of articles (n)	Solar energy	Offshore wind power	Geothermal energy	Hydropower
Australia	AU	163	40	13	32	15
New Zealand	NZ	160	41	3	36	21
USA	US	160	33	19	32	16
Canada	CA	160	36	15	26	24
Ireland	IE	160	59	24	7	11
Great Britain	UK	161	52	17	16	16
Austria	AT	162	34	9	19	38
Germany	GE	164	36	22	17	25
South Africa	ZA	162	82	3	3	13
India	IN	160	56	4	4	35
Indonesia	ID	160	29	0	38	33

with respect to these conditions: (1) hydropower could only be deployed in regions with rivers, (2) geothermal energy could only be deployed in regions with volcanic activity, (3) offshore wind energy could only be deployed in countries with appropriate coastlines and (4) solar energy is more suitable in regions with a high degree of solar radiation. Furthermore, we wanted to consider technologies that can be applied in large- and small-scale projects, such as hydropower and solar energy. We also sought to consider technologies that require large investments, such as geothermal and offshore wind power. Therefore, we selected offshore wind power and not wind power in general.

An article was included in the sample if one of the four energy technologies was mentioned somewhere in the article and if it included at least one problem or benefit of the technology (see **Supplementary Table 2**). This criterion was important to ensure that an article actually provided further information concerning the media's framing of a technology.

To select an approximately equal number of articles per country, newspaper and energy technology, and to ensure reasonable sample sizes for multiple comparisons, a disproportional stratified random sample was used. However, as some energy technologies were not widely discussed in all countries, the number of articles obtained per technology varied considerably. In some countries, offshore wind power and geothermal energy received almost no coverage by the media. These differences can be interpreted as an indication of the relevance of specific national conditions to media coverage on the topic. For example, solar energy is extremely important in South Africa, whereas offshore wind is of little importance there, as well as in New Zealand, India, Austria and Indonesia. The final media sample consisted of at least 160 articles per country, with approximately half before and half after the Fukushima accident (**Table 1**).

Coding Instrument

In content analysis studies in general, but specifically in studies on media coverage of renewable energy, several approaches to framing analysis have been applied. In this study, we used the manual reductionist framing approach, which is suitable to

identify frames from medium to large text corpora (Matthes and Kohring, 2008; Schäfer and O'Neill, 2017). A similar research strategy was exerted by Lück and colleagues to identify frames on climate change in five countries (Lück et al., 2016). A systematic literature review of media framing studies published between 1999 and 2005 (Matthes, 2009) showed that Entman's framing concept is the most dominant, likely because it can be applied to (almost) any social and political issue and because the designation of four concrete frame elements allows for improved operationalisation (Matthes and Kohring, 2008). Therefore, we decided to use Entman's approach and developed a codebook based on the frame elements proposed by him, which included: (1) the *problems vs. benefits* of renewable energy, (2) the *causes/reasons* for the use of renewable energy, (3) the *treatment recommendation* to overcome problems or to harvest the benefits of renewable energy and (4) the *moral evaluation* of actions by involved actors concerning renewable energies (see **Supplementary Table 2**). An article was included in the analysis if it mentioned at least one problem or benefit of renewable energy.

Intercoder Reliability

Due to the nature of our comparative research project, which deals with different languages, cultures and journalistic traditions, the process of measuring intercoder reliability was more complex than in comparative research projects dealing with only one language and one cultural setting. Similar comparative research dealing with multi-language and multi-cultural coders and articles mentioned the same phenomena (Kumpu and Kunelius, 2012). All 11 coders were involved in the process of codebook development. After the codebook was finished, all coders were asked to code 25% of the articles in the analysis. Every article was independently coded by at least two coders. After, they compared their results. If there was a disagreement, coders were asked to discuss the difference, consider possible reasons and finally reach a consensus on a specific code. These final codes were saved in the dataset. At the end of the process, 25% of the sample had perfect reliability, and the coders were extremely well-trained to code the rest of the sample appropriately.

FINDINGS

Three Frames of Renewable Energy

To identify the frames in the coverage of renewable energy, a cluster analysis was conducted to identify homogeneous segments of articles in terms of the aforementioned frame elements.⁶ **Table 2** shows the three clusters found in the 11

⁶Especially when analysing large samples, as in this case, the identified clusters may vary considerably depending on the cluster method used. To overcome this methodological weakness, we used different types of cluster analyses provided by SPSS (version 24) to attain stable and meaningful solutions. We started with a hierarchical cluster analysis using Ward's method and Euclidean distance. To determine the appropriate number of segments, we used the elbow criterion and identified three clusters. In the next step, we applied the two-step cluster analysis with log-likelihood as a distance measure. Bacher et al. (2010) explained that this method is recommended for larger samples. Nevertheless, the obtained results using this method did not deliver any interpretable results. Therefore, we stayed with the results obtained from the hierarchical cluster analysis.

countries along with their characteristics concerning the variables used to identify the clusters. It is remarkable that the variables operationalizing the frame elements *problems vs. benefits* indicate significant differences between the clusters, while only two of the four *causes* show any noteworthy discrepancies. Furthermore, *moral evaluations* significantly differ between clusters, while *treatment recommendations* do not.

The first cluster, labeled the *economic and technological problems frame*, consists of 358 articles (20.2% of the sample). The articles in this cluster emphasize the economic and technological problems of renewable energies, while environmental or social problems are neglected. In contrast, ecological benefits appear more often than problems.

The second cluster is much smaller; only 166 articles (9.4%) are assigned to this frame. As articles in this cluster strongly focus on environmental and social problems, it is labeled the *environmental and social problems frame*. In contrast to the first cluster, economic and technological problems do not play a significant role in this frame. Concerning almost all other frame elements, however, the first two clusters portray a similar picture, with the exception of the dimension of moral evaluation. While the *economic and technological problems frame* is not connected with any moral evaluation of relevant actors, the *environmental and social problems frame* is accompanied by a striking number of articles in which actors are blamed for facilitating the implementation of renewable energies.

The third and largest cluster consists of 1,248 articles (70.4%). Renewable energies are largely framed positively in this cluster. Because of its size and positive tone, this cluster is called the *positive dominant frame*. Environmental, economic and technological benefits of renewable energies are specifically highlighted in these articles; however, benefits to society are also absent in this frame. Nevertheless, *political, social and economic causes* for the implementation of renewable energies are mentioned more frequently within this frame. In contrast to the other frames, the articles belonging to the *positive dominant frame* sometimes portray a positive moral evaluation of those who promote renewable energies.

To illustrate the issues covered in the articles belonging to the three clusters, we selected three examples from each frame. In **Table 3**, the headlines of the articles, the newspapers, the dates and the covered technologies are compiled.

Media Framing of Renewable Energy in 11 Countries

For each country, the percentages of articles containing the respective frames were calculated. The findings revealed specific patterns in the media coverage for each country. Although the *positive dominant frame* monopolizes the coverage in all countries, the percentages vary largely. As **Table 4** shows, newspapers from South Africa, New Zealand and Ireland frame renewable energy most positively; more than 80% of articles in these countries use positive framing. Germany has the least positive coverage, with more than 45% of articles negatively framing renewable energy. The second- and third-least positive

countries are Indonesia and India, in which approximately 36% of media coverage is critical.

Influence of Conventional Energy Resources on the Framing of Renewable Energy

To explain the differences in framing, as posed in the first hypothesis, we classified the selected countries based on their conventional energy resources (see **Supplementary Table 1**). To operationalize the available energy resources in each country (independent variable from H1), we calculated an index summarizing the production of coal, oil, gas and uranium. To make the different measurements comparable, we first standardized the four indicators and then weighted the amount of resources with regard to the country's population size. Through this procedure, we estimated the relevance of the available conventional energy resources for each country. Based on these results, we classified the countries into three groups: Ireland, India and Austria were in a group with relatively few conventional energy resources; Australia, Canada and the US were in a group with abundant resources; and the other five countries were positioned in between.

As **Table 5** shows, H1 was only partly supported. As hypothesized, in countries with a high availability of conventional energy resources, the *economic and technological problems frame* appears more frequently (23.2%) than in countries with fewer conventional energy resources (15.8%) and somewhat more frequently than in countries with a medium amount of gas, coal, oil and uranium resources (21.2%). Contrary to our hypothesis, the *environmental and social problems frame* fails to be more prominent in countries with abundant conventional energy resources; in fact, the opposite is true. Generally, the differences between country groups are not very remarkable.

To test H2, the sample was divided into two groups. The first group contained six countries that obtain at least a small share of their electric energy consumption from nuclear energy; the second group consisted of five countries that do not use nuclear energy at all. Based on this comparison, the findings indicate that the second hypothesis is partly supported by the data. The results in **Table 5** show that the *environment and societal problems frame* is more prominent in countries that use nuclear energy (12.1%) than in those that do not (6.1%). However, concerning the *economic and technological problems frame*, no differences can be observed.

Influence of Installed Renewable Energy Density on the Framing of Renewable Energy

The third hypothesis assumed differences in framing based on the fact that renewable energy facilities can be perceived as disturbing for various reasons, such as noise, aesthetics, health concerns and the suspected depreciation of real properties. To test this hypothesis, the countries were classified based on the density of installed renewable energy facilities. To do so, the amount of energy produced by the four renewable energy resources (in GWh) was summed and weighted by the population

TABLE 2 | Frames and their characteristic frame elements.

	Critical economic and technological evaluation frame	Critical environmental and social evaluation frame	Positive dominant frame	df	F-Score	p
N (% of sample)	358 (20.2)	166 (9.4)	1248 (70.4)			
Economy: problems vs. benefits	−0.64 ^a	−0.03 ^b	0.34 ^c	2	433.7	<0.001
Technology: problems vs. benefits	−0.49 ^a	−0.05 ^b	0.34 ^c	2	374.3	<0.001
Environment: problems vs. benefits	0.17 ^a	−0.72 ^b	0.42 ^c	2	370.1	<0.001
Society: problems vs. benefits	0.00 ^a	−0.66 ^b	0.05 ^a	2	350.4	<0.001
Economic causes	0.06 ^a	0.04 ^a	0.14 ^b	2	13.4	<0.001
Technological causes	0.03 ^a	0.02 ^a	0.03 ^a	2	0.1	n.s.
Environmental causes	0.11 ^a	0.10 ^a	0.14 ^a	2	1.2	n.s.
Social/political causes	0.10 ^a	0.09 ^a	0.20 ^b	2	12.1	<0.001
Treatment recommendation	0.22 ^a	0.19 ^a	0.18 ^a	2	1.2	n.s.
Moral evaluation	−0.03 ^a	−0.23 ^b	0.07 ^c	2	45.3	<0.001

Analysis of variance: means in the same row that do not share superscripts differ at $p < 0.001$ in the post-hoc test (Duncan).

TABLE 3 | Article headlines illustrating the frames.

Cluster	Example		
	Country	Technology	Headlines (newspaper and publication date)
Economic and technological problems frame	Ireland	Solar energy	"Solar power fails to help Philip Lynch" (The Independent, 21 July 2011)
	US	Offshore wind energy	"Will Hurricanes Topple U.S. Wind Turbines?" (The New York Times, 13 February 2012)
	Australia	Solar energy	"\$1.1bn wasted on solar power; Rich favored, emissions unaided" (The Age, 11 November 2010)
Environmental and social problems frame	Canada	Offshore wind energy	"An ill wind blows on Lake Erie; The McGuinty government's response to anger over wind turbines at Point Pelee reveals a green-energy policy in disarray" (The Globe and Mail, 7 September 2010)
	New Zealand	Geothermal energy	"Taupo to host big geothermal energy workshop" (The Dominion Post, 11 June 2011)
	UK	Offshore windfarm	"Comment: 'Peak oil' is a myth: There's enough fossil fuel to fry the planet several times. But only gas can cut emissions" (The Guardian, 19 October 2011)
Positive dominant frame	India	Geothermal energy	"Farooq calls for India-Iceland cooperation in geothermal energy sector" (Hindustan Times, 15 January 2010)
	South Africa	Solar energy	"True costs of nuclear power are ignored Solar park is a step in the right direction Businesses" (The Star, 4 October 2014)
	Australia	Solar and wind energy	"Believe it and we can do it" (The Age, 27 February 2010)

density, which resulted in an indicator for the density of installed renewable energy facilities in each country. Based on this, the countries were classified into three groups: (1) low density of renewable energy facilities (Australia, New Zealand, South Africa and Ireland), (2) high density of renewable energy facilities (Germany, the US and India) and (3) medium density of renewable energies (all remaining countries).

Table 5 shows that the third hypothesis is also partly confirmed: renewable energies are framed more positively in countries with a low density of renewable energy facilities than in countries with medium or high density. By contrast, in countries with a high density of implemented renewable energy facilities, such as Germany, the US and India, many articles framed the environmental and social impacts critically (16.7%). In countries with a medium density, including the UK, Indonesia,

Austria and Canada, the media provided more critical articles toward the economic and technological dimensions of renewable energy (22.7%).

Influence of the Fukushima Accident on the Framing of Renewable Energy

Finally, the impact of the Fukushima accident on the media's framing of renewable energy was examined. The Fukushima accident did not lead to a more positive framing of renewable energies; in contrast, the framing became even more critical (see Table 6). After the Fukushima accident, the *economic and technological problems frame* increased from 17.7% to 22.6%. Based on this result, H4 must be rejected. To test H5, the changes in coverage in countries that use nuclear energy were compared to the changes in those without nuclear energy. Based on this

TABLE 4 | Frames of renewable energy in the 11 countries.

	Critical economic and technological evaluation frame	Critical environmental and social evaluation frame	Positive mainstream frame	df	χ^2	p
N (% of sample)	358 (20.2)	166 (9.4)	1248 (70.4)			
Germany	26.2	18.9	54.9	20	111.7	<0.001
India	18.8	17.5	63.7			
Great Britain	19.9	12.4	67.7			
USA	18.1	13.8	68.1			
Austria	17.9	13.0	69.1			
Indonesia	30.6	5.6	63.7			
Australia	28.8	3.7	67.5			
Canada	22.5	6.9	70.6			
South Africa	16.0	3.1	80.9			
New Zealand	12.5	4.4	83.1			
Ireland	10.6	3.8	85.6			

TABLE 5 | Effects of structural conditions on the media's framing.

	Critical economic and technological evaluation frame	Critical environmental and social evaluation frame	Positive dominant frame	df	χ^2	p
CONVENTIONAL ENERGY SOURCES						
N (% of sample)	358 (20.2)	166 (9.4)	1248 (70.4)			
Countries with low availability (IE, IN, AT)	15.8*	11.4	72.8	4	10.9	<0.05
Countries with medium availability (NZ, UK, GE, ZA, ID)	21.1	8.9	70.0			
Countries with high availability (AU, CA, US)	23.2	8.1	68.7			
NUCLEAR ENERGY						
N (% of sample)	358 (20.2)	166 (9.4)	1248 (70.4)			
Countries without nuclear power plants (AU, NZ, IE, AT, ID)	20.1	6.1	73.8	2	19.3	<0.001
Countries with nuclear power plants (US, CA, UK, GE, IN, ZA)	20.3	12.1	67.6			
INSTALLED RENEWABLE ENERGIES						
N (% of sample)	358 (20.2)	166 (9.4)	1248 (70.4)			
Countries with low density (AU, NZ, ZA, IE)	17.1	3.7	79.2	4	67.7	<0.001
Countries with medium density (CA, UK, AT, ID)	22.7	9.5	67.8			
Countries with high density (GE, US, IN)	21.1	16.7	62.2			

*Reading example: For countries with low availability of energy resources, 15.8% of all articles were coined by the critical economic and technological evaluation frame.

comparison, H5 must be rejected as well. In both subgroups, the picture was similar. Only with respect to the *environmental and social problems frame* did the coverage became somewhat less negative in countries that use nuclear energy (Table 6).

DISCUSSION AND CONCLUSIONS

The aim of the study was to examine the media's framing of renewable energies in different countries and provide explanations based on the national structural conditions and the Fukushima accident. This study builds on the premise that—besides direct experience and (mediated) interpersonal communication—mass media remain highly relevant for the public discourse on topics like renewable energy. Mass media provide a forum where relevant actors from politics, the economy and other groups of society struggle to get their perspectives

published. However, the media not only transfer the messages from these actors to the public but also actively frame the issues by selecting and highlighting specific aspects of the topic. These depictions of renewable energy are important factors influencing public acceptance and usage (Van Dael et al., 2017; e.g., Çakırlar Altuntaş and Turan, 2018).

In general, our findings revealed three different ways of framing renewable energies in the media: the first frame emphasizes the positive aspects of renewable energies (*positive dominant frame*), the second focuses on economic and technological problems of renewable energies (*economic and technological problems frame*) and the third highlights environmental and social problems (*environmental and social problems frame*). Overall, a positive framing was predominant; only 30% of the articles contained the two negative frames.

TABLE 6 | Influence of Fukushima incident in countries with and without nuclear power plants.

		Critical economic and technological evaluation frame	Critical environmental and social evaluation frame	Positive dominant frame	df	χ^2	p
N (% of sample)		358 (20.2)	166 (9.4)	1248 (70.4)			
Whole sample	Before Fukushima	17.7	9.7	72.6	2	6.4	<0.05
	After Fukushima	22.6	9.1	68.4			
Countries not using nuclear energy	Before Fukushima	17.9	5.9	76.2	2	2.4	n.s.
	After Fukushima	22.2	6.3	71.6			
Countries using nuclear energy	Before Fukushima	17.6	12.8	69.7	2	4.3	n.s.
	After Fukushima	22.9	11.5	65.6			

However, our findings also indicated considerable differences in the framing of renewable energy between the countries under investigation, which to some degree could be attributed to national structural conditions. In countries that have a high availability of conventional energy resources (gas, oil, coal and uranium) per inhabitant, the media more frequently emphasized economic aspects; they criticized the demand of high investments for employing renewable energies and underlined the assumed economic benefits of fossil fuels. However, countries with a limited availability of conventional energy resources per inhabitant framed renewable energy more positively. For these countries, the new technologies might have positive consequences for the economy and securing the national energy supply. The issue of national energy security is becoming increasingly relevant due to greater pressure to reduce carbon emissions and the concentration of fossil resources in countries such as Russia, China and the Middle East (Cox, 2016). Thus, media coverage on renewable energy in countries with limited availability of conventional energy resources frames the issue more positively than media coverage in countries with abundant resources.

With the expansion of renewable energy installations, the negative consequences for the environment and society (e.g., landscape changes caused by the installation of wind turbines) became visible, and consequently, opposition and skepticism among the public rose, which was reflected by the media. This explains why the media in countries with a high density of installed renewable energy facilities, such as Germany, the US and India, used the critical environmental and social evaluation frame more frequently in their articles. In general, the existence of frames highlighting the problems with renewable energies could be either a threat to or an opportunity for the development of renewable energy. It is a threat if the number of critical and skeptical articles dominates the media agenda, creating a public opinion in opposition to renewable energies. However, if journalists consider existing problems as an occasion to dig deeper and cover solutions to overcome them, this could also be considered an opportunity (Entman, 2003).

Generally, national structural conditions provide opportunities and restrictions for specific persons and groups of society that are connected with specific interests. On the one hand, owners of natural resources and related companies have an interest to exploit them. By doing so, they provide job

opportunities and income for employees in these industries. On the other hand, the exploration of resources also has negative ecological and social consequences. For example, surface mining destroys entire landscapes, and people living in the affected areas may lose their homes. Thus, the use of specific energy technologies is connected with conflicting interests, and the disputing groups try to affect the media's framing of the issue in a favorable way to receive public support for their objectives and interests.

In turn, the media, including journalists, are keen to reflect and articulate their audiences' perspectives on the issue, as they—to a certain extent—depend on public acceptance. From this perspective, the natural structural conditions may either strengthen or weaken the position of specific groups, as their size and power depends on these conditions, which ultimately helps them develop public influence.

In general, the national structural conditions are quite stable. However, focusing events, like economic crises or disasters, have the potential to disrupt institutional settings and lead to changes in the coverage of renewable energy. The current findings show that the Fukushima accident changed the media coverage on renewable energy in an unexpected, negative direction. However, our data do not provide any explanation for these surprising findings.

One potential explanation for the results might be the differential power of actors and lobbyists from different sectors of the energy industry in influencing the media. While the powerful fossil fuels and nuclear energy industries certainly affirmed that traditional energy generation is still more lucrative than renewable energy, despite its dangerous consequences for the environment, advocates of renewable energy failed to use the Fukushima accident to create public support for renewable energy as a clean and safe replacement of nuclear energy.

LIMITATIONS AND FUTURE RESEARCH

Although the present study adds valuable knowledge to the research on the media's framing of renewable energy, several limitations should be recognized. The first limitation is that the selection of countries and newspapers included in this study was restricted by the coders' language proficiency and by access to the specific newspapers available in the LexisNexis database.

Second, we had to disregard organizational influence. Previous research has shown that political orientation is related not only to attitudes toward climate change (McCright et al., 2013) but also to peoples' acceptance of and beliefs about renewable energy (Karlström and Ryghaug, 2014; Arpan et al., 2018). Because news production is influenced by organizational factors (Shoemaker and Reese, 2014), future research should consider the political leanings of newspapers and the characteristics of the readership. A multi-national research team is highly recommended for such a project.

Another limitation is that the analysis included a small number of national structural conditions, which could influence the framing of renewable energy; there are many other influencing factors that should be considered. For example, variations in the potential for using various renewable energy resources between countries could be important. Countries with long coastlines and continuous strong winds have greater potential for offshore wind turbines, whereas those with intense solar radiation have better conditions for solar energy. Furthermore, the geological characteristics of a country influence its potential use of renewable energy sources. Such country-specific conditions for using renewable energy technologies are also likely to affect media framing. Furthermore, national-level energy policies, the power of lobby groups and political and economic dependencies could also have a significant influence on the framing of renewable energy by national media outlets. Therefore, it is necessary to code the appearance of political actors in the media and their statements on the topic.

Future studies should also consider opinion polls to determine the extent to which media coverage is oriented toward public opinion. It would also be beneficial to address the different cultural orientations of populations to examine whether the basic social orientation of a society favors renewable energy. With respect to such cultural orientations, Hofstede et al. (2010) and Schwartz (2006) demonstrated that people from different countries typically handle uncertainty differently. In this context,

countries that tend to avoid uncertainty may also be more hesitant to rely on renewable energy. Likewise, whether a society is more present- or future-oriented could also significantly affect the diffusion of renewable innovations.

Moreover, it is necessary to include a broader range of countries, including developing and emerging countries, with a variety of structural, political and social conditions as well as political leanings of the mass media under investigation. Furthermore, we would not recommend limiting the analyses to selected technologies as we did in our study but instead advocate for including the complete range of renewable energies and aspects of energy storage and transmission, which are also highly discussed in many countries.

Finally, we recognize that in a quantitative, comparative study investigating several countries simultaneously, the peculiarities of single countries—their histories, their legal systems, their national narratives and their policy decisions—cannot be considered as in a case study of one or a few countries.

AUTHOR CONTRIBUTIONS

All authors contribute equally in conducting the research and writing the manuscript.

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SUPPLEMENTARY MATERIAL

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